Picture This! Community-Led Production of Alternative Views of the Heritage of Gwynedd

Karl, Raimund; Roberts, Jonathan; Wilson, Andrew; Möller, Katharina; Miles, Helen Charlotte; Edwards, Ben; Tiddeman, Bernie; Labrosse, Frédéric; La Trobe-Bateman, Emily

Published in:
Journal of Community Archaeology and Heritage

DOI:
10.1179/2051819613Z.0000000003

Publication date:
2014

Citation for published version (APA):
Karl, R., Roberts, J., Wilson, A., Möller, K., Miles, H. C., Edwards, B., Tiddeman, B., Labrosse, F., & La Trobe-Bateman, E. (2014). Picture This! Community-Led Production of Alternative Views of the Heritage of Gwynedd. *Journal of Community Archaeology and Heritage*, *1*(1), 23-36. https://doi.org/10.1179/2051819613Z.0000000003

Prof Raimund Karl
Prifysgol Bangor University
College Road
Bangor, Gwynedd LL57 2DG
United Kingdom
+44 7824 527165
r.karl@bangor.ac.uk

Co-authors: Dr Jonathan Roberts (Prifysgol Bangor University), Dr Andrew Wilson (Prifysgol Bangor University), Katharina Möller (Prifysgol Bangor University), Helen C. Miles (Prifysgol Bangor University), Dr Ben Edwards (Manchester Metropolitan Universty), Dr Bernard Tiddeman (Aberystwyth University), Dr Frédéric Labrosse (Aberystwyth University), Emily La Trobe-Bateman (Gwynedd Archaeological Trust)

Picture this!

Community-led production of alternative views of the heritage of Gwynedd

Abstract: The digital camera has become ubiquitous. Every mobile phone has one built in, almost everyone has a mobile phone and people use them constantly for all kinds of things, including taking pictures. In a new collaborative project, funded by the Arts and Humanities Research Council (AHRC), Bangor, Aberystwyth and Manchester Metropolitan Universities have teamed up with Gwynedd Archaeological Trust to develop tools to allow communities to picture their heritage and upload the images to an automated photogrammetry server to create metrical 3D models of the sites and objects they are recording. The data created will then feed into the local Historic Environment Record, providing a valuable tool for monitoring changes to heritage sites, while providing communities with added information and alternative views of their heritage. This paper is not intended to provide a formal research design or a fully developed prototype. Rather, it is intended to outline an experimental and collaborative approach that is situated as *both* practice and research, with neither enterprise being privileged over the other. The activities outlined here will be developed and evaluated over the next year and a half, after which we will report on whether or how the contingent aims and outcomes expressed were realized.

Keywords: photogrammetry, 3D visualization, heritage management, Historic Environment Record, citizen science, community research

In the United Kingdom 10 years ago, a digital SLR camera had 6 megapixel resolution and cost about £1,000. Now, the digital camera on a handset that is thrown in 'free of charge' with any mobile phone contract has at least that, if not a considerably higher resolution. People use their camera phones to take pictures of everything, and to upload the images to all kinds of online services. Many of us want to share our images and, by and large, want them to be useful for someone else, whether for plain entertainment, education or research. People particularly like to take pictures of things they care about, whether it is themselves, their friends or anything they like (Van House 2011), including, not least of all, monuments and anything they consider their heritage.

The Internet has changed the way we share photographs. With the popularity of photo sharing websites, photography is no longer restricted to galleries or prints. In the past decade, photoblogs and digital galleries, such as flickr[i], Photobucket[ii] and Instagram[iii], have revolutionised the way we view photographs. These digital galleries have become a convenient place to share photos, enabling the user to share with a select few friends and family or the entire internet. These photo sharing websites have given a sense of neighbourhood participation, creating online 'communities'. This has also increased the popularity of sharing photos through social networks (also of archaeological excavations[iv]).

Social Networks have allowed sharing of a much more personal nature, enabling users to share photos with only those they specify, whether it is all users, or only those whom they are connected with. The use of Social Networks have also increased photo sharing via mobiles phones. This has led to several new networks and applications capable of sharing photos directly from mobile phones, the most prominent being Instagram. As a result, some of the photo sharing sites that host these images have become useful sources of free or low-cost images. Many of these sites also include enough features to be seen as practical tools for managing and organising individual collections of images.

Photogrammetry has developed immensely over the last few years too. These days, there are several applications available online which allow the user to (more or less) automatically create 3D models from randomly taken photographs of the same object. Archaeology has started to use these solutions in various ways, not least in the photographic recording of excavation trenches and upstanding monuments (Roe 2010; Doneus et al. 2011; Brown and Karl 2011; Verhoeven et al. 2012; Morton Williams et al. 2012), where the ability to re-create 3D models of surfaces is clearly preferable to simple 2D records. For example, rather than having to rely on sections (whether drawn or photographed) decided on site during the excavation or surveying of a site or monument, any desired section can later be re-constructed back in the office. Similarly, rather than having to rely on plans with a couple of levels taken in more or less random positions, one can get reasonably accurate levels of any point of a recorded area. This greatly enhances the possibilities to understand and re-interpret records created during invasive procedures.

3D volumetric modelling of upstanding heritage also clearly provides significant benefits for heritage management. If metrical 3D models created from data collected at different dates are compared, changes to the substance of monuments are easily and automatically detectable, even if they are invisible *in situ* to the naked eye of an expert. Such volumetric remote monitoring has already been conducted using LIDAR, especially on a landscape scale (e.g. on the Danewerk in Schleswig-Holstein, pers. comm. U. Ickerodt). However, airborne and ground-based LIDAR surveys and the equipment to conduct them are still relatively expensive, still require specialist surveyors to carry out the work and thus come with a considerable price-tag attached. They also have the disadvantage that they are not overly detailed unless carried out specifically with the aim of recording monuments. As a result, they often only detect major changes, while missing changes in the centimetre range, and can therefore only document massive erosion events or equally significant human-

induced damage. In comparison 3D volumetric photogrammetry can achieve accuracy in the centimetre range relatively easily, and can be produced with relatively little effort. In theory, almost any set of randomly taken digital photos with sufficient metadata attached can be used to create a reasonably accurate 3D volumetric model of a monument or site. Any such model can then automatically be compared to earlier, similarly created models. Changes in the centimetre range can be automatically highlighted, and a warning can be sent to the responsible curator if change to the structure of the monument exceeds a certain pre-defined threshold.

However, even this still requires someone to take the pictures, create reasonably accurate 3D models, and compare these with earlier records. For heritage agencies, sending out a staff member to take these pictures and produce the models costs staff time and money. That time and money may be available for occasional monitoring, but certainly not in sufficient amounts to enable regular and frequent site visits by archaeological staff – at least not in North Wales.

But what if we could use the ubiquity of the digital camera in the hands of interested members of the public, who are enjoying themselves out in the countryside and like to take pictures anyway? If we recruit help from those people who care greatly about their heritage and want to contribute to its preservation and understanding? Or, if we want to hear the voices of those who, instead of being told by academics and heritage managers what should be preserved in their interest, want to preserve what they are actually interested in? It would seem that where photographic recording of heritage is concerned, the interests of academia, heritage management and the public are almost perfectly aligned. All that is needed are the tools to serve everyone's interests equally and at the same time empower people to decide what heritage they want to engage with, preserve, research, make publicly available and tell stories about.

This is the starting point for a new project, 'Co-production of alternative views of "lost" heritage', funded by a large AHRC 'Digital Transformations in the Humanties' grant, and conducted collaboratively by Bangor, Manchester Metropolitan and Aberystwyth University together with Gwynedd Archaeological Trust (GAT) and the local community, which has just started. We have previously been engaging with visual heritage data, partially produced with the help of local volunteers, in a series of projects aimed at making data held in the Historic Environment Record (HER) for Gwynedd (north-west Wales, fig. 1) available to the public more effectively. Now we want to take this a step further and provide everyone with the means to create more data. While in this article, we introduce the project and try to draw out its aims and objectives and the thinking that led us to develop it, we aim to revisit it in a subsequent paper to reflect on whether we achieved what we intended, and learn lessons for the future.

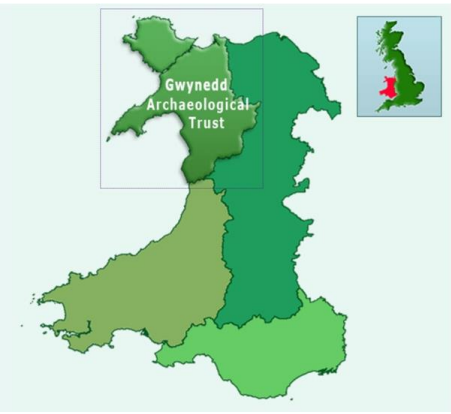

Fig. 1: Area covered by the North West Wales HER (http://www.archwilio.org.uk/)

Previous projects

The Welsh Archaeological Trusts, through their *Archwilio* Online HER[v], have been at the forefront of making written records available easily and openly to all interested parties across the whole of Wales[vi]. In addition to written data, a huge amount of visual information has been archived, mostly in the form of photographic records. In the Technology Strategy Board-funded Knowledge Transfer Partnership project 'Digital Media and Public Archaeology' (still ongoing), GAT in collaboration with the School of History, Welsh History and Archaeology at Bangor University has been training local volunteers to scan the sizeable slide collections of the two partner institutions in this project. The aim of this project is to make that visual data, with relevant metadata added, publicly available via *Archwilio* (James 2011) on-line and a free Android *Archwilio* App (see Google Play for this). This App already includes a function to allow registered users to upload photographic images and add comments to site records. In a follow-up AHRC 'Science and Heritage' scheme funded project, 'Alternative views of the "lost" heritage of Gwynedd', the original partners in the KTP teamed up with the School of Computer Science at Bangor University and the Department of Computer Science at Aberystwyth University. This project started to examine the technical possibilities to use archival photographic records to create 3D models of 'lost' heritage. 'Lost' in this context refers to heritage which has been photographically recorded in the past, but may since have changed, whether just minimally through natural erosion, or fundamentally by having since been excavated and built over.

Both these projects, however, were still focused on making heritage data considered to be important by professional archaeologists available to the public, rather than transferring (at least some of the) decisions as to what is significant heritage to local communities into the hands of members of these communities. The new collaborative project 'Co-production of alternative views of "lost" heritage' now aims at giving these communities means of preserving by record what they consider is important to them. They can then feed that information into professional archaeology and into heritage management. We also aim at giving them a role in quality control of records, and monitoring of the heritage chosen by them, and allow them to record their own stories and memories about that heritage. In this, we are partially following and expanding on earlier examples set by (for example) English Heritage in developing community involvement in and researching community engagement with and interests in heritage, particularly among young people, and especially using photography as a hook (Bradley et al. 2011).

Fig. 2: A member of staff, a local work experience student and a German excavation tourist, taking pictures of features for 3D modelling on a Bangor University excavation in Meillionydd in summer 2013 (© 2013 François Ohl)

Consulting the community

Over the course of the last few years, within the projects mentioned above and various field projects, we have been working with various segments of the local communities to develop possibilities for them to engage with archaeology, and to understand their interests about how they would like to engage with heritage. For instance, in the 'Digital Media and Public Archaeology' Knowledge Transfer Project, we provided the facilities and created the procedures and structures required for scanning the archaeological slide collections of Bangor University and Gwynedd Archaeological Trust. The scanning of the slides and adding of the associated metadata, on the other hand, is carried out by a community of keen volunteers, who are highly interested in working with archaeological photographs. For them, the possibility to add their own photographs of their local heritage to the HER, and possibly even contribute to the monitoring of the sites they themselves are particularly interested in, seemed a very attractive proposition. In the KTP project just mentioned, and in the 'Alterative views of the "lost" heritage of Gwynedd' project, we have also been working with local artists and schools (for example, creating a local travelling exhibition, where the possibility to create 3D models from photographs also seemed attractive to various parties). In our archaeological field projects with opportunities for community and tourist participation, the creation of 3D models of trenches and excavated features from photographs taken on site also met with considerable interest (fig. 2). At the same time, the importance of storytelling and other creative narratives (whether oral, visual or physical) emerged as a distinct community interest. For instance, while working with some of our local partners on the Llŷn peninsulavii, the importance of ancient and more modern narrativesviii associated with heritage sites became very evident on many occasions. Generally, the possibility to take photos and do something interesting with them, whether telling stories or creating visualisations, clearly created considerable interest among participants and visitors alike (fig. 3). This fed directly into the project design, even though the various communities involved had no direct input into the writing of the grant application.

Fig. 3: 3D model of a trench at Moel Fodig hillfort, created from photos taken by local volunteers (© 2012 Prifysgol Bangor University)

Problems to solve

Of course, to create a possibility for various communities to play with and contribute their pictures and stories of heritage, technical problems will need to be solved. Not the least of these is to create an easy to use online system for uploading photos, automatically calculating volumetric 3D models from them, linking the pictures and models with already existing HER records, and ensuring sufficient quality control of the data and metadata produced. This is one of the areas where we will try to develop solutions that are easy to use

and allow the production of solid 3D models with as little effort as possible. Challenges will also have to be overcome where the community involvement is concerned, and these may be of much greater significance than the technical problems.

While calculating 3D models from more or less randomly taken photographic records is possible, not every set of photos works well, and some do not work at all. Thus, to achieve good results (and to provide early adopters in the community with positive experiences of working with the online modelling system even in their first attempts to use it) training opportunities will be provided to those volunteers already working with photographic HER data and other interested members of the local community, and also to students in collaboration with schools in north-west Wales. Logistical support will also have to be provided, particularly in the trial phase: landowner permission will be needed for some monuments, guidance provided on safety and legality when photographing sites, site lists will be compiled highlighting particularly well-suited sites, and instructional material on photogrammetry will need to be produced and disseminated to interested parties.

Particularly in the early stages, monitoring of the quality of the data produced and the success of the training activities to provide community members with the necessary skills will also be essential. In the medium term, we hope that (using the interaction tools developed by us) a community-led, Wikipedia-style moderation structure will develop in which experienced members of the community can provide data quality control. This should make the project's core element, the community-led data collection, model production and quality control into a self-sustaining, self-perpetuating system which can be run entirely by the community itself without any major input by professional archaeologists (while still providing the data to the HER to enable curators to monitor changes to those sites chosen by the community as its heritage, and where necessary act to protect and preserve it).

At least to start with, we plan to focus on several, partially interlinked communities. One strong focus will be on the volunteers already participating in various community archaeology projects across North Wales. Whether their current engagement is more desk-based or field-based, they already engage significantly with archaeology and particular archaeological photography and thus are a natural first point of call. We also aim to engage the metal detectorist community, which already contributes valuable information about archaeological heritage via the Portable Antiquities Scheme[ix]. The metal detecting enthusiasts are out in the fields and usually quite technology-savvy, and at least partially are already using their mobile phones to record the locations of any finds they have made via their phones' inbuilt GPS locator. Using another function of their phones, to take pictures of heritage they encounter while out detecting, will hopefully come naturally to them and add another exiting aspect to their hobby while further increasing their contribution to the understanding of archaeological heritage. Another community we target consists of heritage tourists: heritage tourism is a major economic factor in Wales in general and North Wales in particular (Abb. 4). The project will provide a particularly welcome opportunity to improve the experiences of visitors to the area by giving them an opportunity to contribute to the enhancement and protection of the heritage of the area. Taking photos of what one is visiting is what tourists, and particularly heritage tourists do, if only to have mementos of what they visited. Providing them with a chance to not just put their holiday shots on flickr, Photobucket and Instagram or create a slide show for their relatives and friends, but play with their photos, create 3D models to really excite their friends, and even contribute to the preservation of the sites they visited will hopefully result in considerable value being added to their holidays. In terms of providing training to tourists, this can easily be done via YouTube videos, for example.

Fig. 4: Dolbadarn Castle, Llanberis (© 2004 Raimund Karl)

Finally, we also want to target school children, especially in the Welsh language, to allow them to play with their heritage and at the same time, learn valuable skills in various subjects. With Welsh (pre-) history being an important element to the Welsh National Curriculum, being able to directly engage with the physical remains of their past will naturally contribute to history teaching, and in an exciting 'modern' way at that. For students to be able to tell stories, whether factual or fictional, about their heritage will not be just enjoyable, but will also increase linguistic and creative skills. In addition, the technical element of taking archaeological photographs with ranging poles or other scales included, and the metrical elements of photogrammetric technology, will be useful for training in more 'scientific' subjects like mathematics, physics and geography; all while playing with fancy technology and creating 'cool' 3D models (which look as if they come out of and could perhaps even directly be imported into some current computer games).

Project evaluation

As part of our research design we will evaluate three main aspects of the project: community response, photogrammetry results and technological feasibility.

To evaluate the community response, we will conduct questionnaire surveys with users as well as with non-users. These will mostly be analysed quantitatively. Furthermore, we will carry out qualitative interviews with users, to gain more detailed data about user satisfaction and requests for changes and upgrades. Also the uploaded content will be analysed. In terms of community response this will include qualitative content analyses of text entries to the HER database and comments on the system. Additionally, hits on the website, numbers of uploaded pictures and successfully calculated 3D models will be monitored. A diachronic comparison of such user interests and input will also allow us to evaluate community uptake.

The pictures and 3D models will be subject to a qualitative analysis as well. First of all, they will have to be assessed by a moderator or super-user, and if deemed suitable, accepted before they will appear on the website. This will not only allow us to ensure a certain quality but also enable us to sort out any problematic images prior to publication. As for 3D models per se, if the pictures used to create such a model do not reach a certain standard the model will not calculate successfully to begin with. Last but not least we did create some models ourselves (and will continue to do so). These will allow us to compare the quality of our models to those uploaded by users. These three things taken together allow us to evaluate the photogrammetry results.

Finally, overcoming the technological issues will also serve to evaluate the project's success. While working 3D photogrammetry solutions do already exist, making them available online will itself be a challenge. Implementing a working online 3D photogrammetry server will thus be the first major test for the project. The user-friendliness of the online system will also be a major issue and will be alpha-tested and evaluated internally before being rolled out to a select group of volunteers as beta-testers. Only after feedback from the beta-testers has been received and implemented will the system go live. Once live, we will also continue to monitor uptake and user feedback on the systems usability and where necessary respond by developing upgrades or tweaks to make the system better at the user end.

An archaeology computer game and community

In a way, we hope that the system can become almost a game in its own right. Users will be able to play the game by taking pictures, uploading them to a server that processes the information, and a result (in our case a three-dimensional image) will be returned to them, along with recorded metadata. Similar games (for example, paper doll creators) can already be found on the internet[x]. Some of them let the user create characters or scenes from favourite tv shows or movies, share dolls and comment on them or those of others. These existing games prove that this process is rewarding and engenders enthusiasm amongst the players: they blog, tweet and discuss with their friends and encourage more users to play. Much like those games, from another angle this project's photogrammetry website should become a social network. Users interact with the system and each other via comment functions on images and their profile pages, and thus participating becomes a social activity and the site a virtual meeting place. Presumably this system will follow the 80/20 rule of thumb, where 20% of the users will take 80% of the photographs. These are Pareto distributions, which can be seen all over the web, from Tweeting to Blogging (Buchanan 2003, 204; Ediger et al. 2010, 587; Newman, Barabási and Watts 2006). These users become experts who can then advise and monitor the social place.

We hope that this Wikipedia-style community will develop organically once an initial group of earlier adopters has been trained by us to use the system and provide the necessary quality control. We realize that this may not happen, and that being self-sustaining is a goal not a reality, but there is precedence for such things working – not least Wikipedia itself. On the technical side, this needs to be enabled by integrating moderation tools and different levels of access into the code of our online photogrammetry and *Archwilio* websites. This will be achieved by using standard open source Wikipedia code, which allows an administrator to define different permissions for different user groups. Starting out with the academic staff in the project as super-users, this system of permissions hierarchies will be used to train and then turn into super-users members of the community. These then in turn can train additional moderators and higher-level users, making the system self-sustaining and handing control to the community itself. One means of evaluating the experience of participants will be to see whether this community becomes self-sustaining over the 1 ½ years of the project is funded, and starts to produce the high-quality data for heritage management we are hoping for. By maintaining a parallel structure that is independent of, but feeds into, *Archwilio*, only images that have been moderated (to prevent uploads of inappropriate images) and 3D models that have been quality-controlled will feed into the online HER. We intend to make available the necessary technical infrastructure (hosted initially on a dedicated server at Bangor University) beyond the end date of the funded project itself for c. 5-10 years if a self-sustaining online community has developed by the end of the project. Hopefully, the provision of the technical infrastructure will also become self-sustaining in the long run (e.g. via crowd-funding[xi]).

Stories, not just images

It is not just the images that we want to capture by creating this tool: the project is also about information, stories and memories associated with heritage. The Faro Convention (CoE 2005) highlights the right of everyone to not just benefit from, but also to enhance their heritage. Providing the possibility for people to record and make publicly accessible the various stories, myths and memories associated with their heritage is integral to the project.

Not just in North West Wales, many monument and heritage sites are traditionally associated with myths, legends and memories of all kinds. Storytelling traditions are still alive, with many of the age-old Welsh legends like the *Mabinogi* intimately linked with the historic landscapes of Wales. To provide just one example, the hillfort of *Dinas Dinlle* just outside of Caernarfon is mentioned in the fourth branch of the *Mabinogi* as the place where *Llew Llaw Gyffes*, one of the main protagonists of this branch, was brought up (Gantz 1976, 109). Similar stories, whether first recorded in the Middle Ages or invented quite recently, are part of a living tradition of engaging with heritage sites, of investing them and the historic environment they inhabit with meaning and significance.

As yet, Historic Environment Records and similar heritage management databases and archives mostly or even exclusively contain academic narratives. They give the likely dates of sites and monuments, what archaeological work has been conducted on them and its results, and what steps have been or need to be taken to preserve the site or monument. While these records do of course invest the respective site or monument with some (mostly academic, historical) meaning and significance, they rarely capture the whole range of meanings they are invested with by the wider community, and do not fully recognise their significance.

By encouraging people to photographically record their heritage and create photogrammetric 3D models, which can then be used to monitor change in the substance of these sites or monuments, we hope that we can also encourage communities to record wider definitions of meaning. We do not think that this will dilute the academic information available about these sites and monuments, but instead will enhance it: after all, the cherished stories associated with them, whether old or new, are intangible heritage, and can be more ephemeral and less durable than the material remains they have become attached to. Rather than academics and curators being sole decision-makers about what information is worthy of preservation and what is not, we aim to develop a simple way in which communities, local and on-line, can record ephemeral meanings associated with sites and monuments.

Questions for the future

In sum, as we evaluate and report on what happens with the provisional ideas outlined here, we will have several questions in mind, some of which have been noted above:

1. Is the underlying technology working successfully?
2. Have members of the public started to engage meaningfully with the system?
3. Does it seem as if the system is becoming a self-sustaining system and community?
4. Has a more meaningful public engagement with heritage developed or are there at least signs that such a more meaningful engagement with heritage is developing among the public?
5. Do images, 3D models and stories collected through this system provide tangible benefits for the management of the heritage?

The main outcome of our project will be a system for producing an archive of images and associated stories created and maintained (hopefully in perpetuity) by many different communities, for everyone. This archive will help heritage professionals with the

management of sites and landscapes, empowers people to decide what they (rather than just the professionals) consider to be important about their heritage, and which can be added to and modified as deemed necessary by its participants. If you would like to get involved, just be in touch by visiting our website[xii].

Acknowledgements

We would like to thank the Technology Strategy Board and the Arts and Humanities Research Council for funding our research. We are indebted to the numerous local volunteers, workplace students, site visitors and excavation tourists who have contributed ideas, labour and immense amounts of goodwill to previous and ongoing projects.

Notes on Contributors

Raimund Karl is Professor of Archaeology and Heritage at Bangor University, Wales, United Kingdom. He recently published a monograph on archaeological heritage management in Austria, Archäologischer Denkmalschutz in Österreich (2011). Bangor University, College Road, Bangor, Gwynedd LL57 2DG, United Kingdom. r.karl@bangor.ac.uk

References

Bradley, David, Mike Coombes, Jane Bradley, and Emmanouil Tranos. 2011. *Assessing the importance and value of historic buildings to young people. Final Report to English Heritage, January 2011*. Newcastle: Newcastle University – CURDS. http://www.english-heritage.org.uk/publications/historic-buildings-young-people/importance-value-historic-buildings-young-people.pdf accessed 7/10/2013.

Brown, Ian, and Raimund Karl. 2011. *Caer Drewyn and its Environs. Site surveys and analyses 2010-2011. Excavations at Moel Fodig hillfort, August 2011*. Interim Report. Bangor Studies in Archaeology Reports No 5, Bangor/Gwynedd.

Buchanan, Mark. 2003. *Small World: uncovering nature's hidden networks.* London: Orion Books Ltd.

CoE 2005. *Council of Europe Framework Convention on the Value of Cultural Heritage for Society*. CETS No. 199, http://conventions.coe.int/Treaty/Commun/QueVoulezVous.asp?NT=199&CM=8&CL=ENG accessed 23/9/2013.

Doneus, Michael, Geert Verhoeven, Martin Fera, Christian Briese, Matthias Kucera, and Wolfgang Neubauer. 2011. From Deposit to Point Cloud: a Study of Low-cost Computer Vision Approaches for the Straightforward Documentation of Archaeological Excavations. *Geoinformatics* 6: 81-8.

Ediger, David, Karl Jiang, Jason Riedy, David A. Bader, Courtney Corley, Rob Farber, and William N. Reynolds. 2010. "Massive Social Network Analysis: Mining Twitter for Social Good." In *Proceedings of the 39th International Conference on Parallel Processing ICPP 2010 13-16 September 2010 San Diego, California, USA*, edited by Patrick Kellenberger, 583-593. Piscataway: IEEE Computer Society.

Gantz, Jeffrey. 1976. *The Mabinogion*. London: Penguin.

James, Sian. 2011. *Visualising the Archaeology of Gwynedd*. http://www.heneb.co.uk/visualising.pdf, accessed 23/9/2013.

Morton Williams, Sarah, Katharina Möller, Ian Brown, and Raimund Karl. 2012. *Hillforts of North Wales: Moel Fodig. Excavations 2011-2012.* Interim Report. Bangor Studies in Archaeology Reports No 7, Bangor/Gwynedd: SHWHA.

Newman, Mark, Albert-László Barabási, and Duncan J. Watts, edit. 2006. *The Structure and Dynamics of Networks*. Princeton: Princeton University Press.

Roe, Martin. 2010. *3D Modelling with AgiSoft PhotoScan. Tests to determine the suitability of AgiSoft PhotoScan for archaeological recording.* Meerstone Arch. Consultancy: http://www.meerstone.co.uk/publications/35-3d-modelling-2.html (accessed 17/6/2013).

Van House, Nancy A. 2011. Personal photography, digital technologies and the uses of the visual. *Visual Studies* 26:2: 125-134.

Verhoeven, Geert, Michael Doneus, Christian Briese, and Frank Vermeulen. 2012. Mapping by matching–A computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs. *Journal of Archaeological Science* 39/7: 2060-70.

[i] http://www.flickr.com/
[ii] http://photobucket.com/
[iii] http://instagram.com/
[iv] e.g. https://www.facebook.com/meillionydddig
[v] http://www.archwilio.org.uk/
[vi] Indeed, the Archwilio App can be seen as a pilot project for what we are attempting to do. While this system at the moment does not allow to create 3D models from uploaded pictures, much of the structure we will create for the project is already in place there, including an upload system for images, a text editing system, and a hierarchy of user groups with different access rights: superusers who can do everything, administrators who have the possibility to create and change entries onto the HER, moderators who can edit and reject or accept new uploads by users, and general users who can upload images and suggestions for additions and changes to existing entries on the her, but whose entries need to be accepted by moderators. We encourage readers to download the Android app to try it out themselves.
[vii] e.g. http://www.felinuchaf.org/1/index.html
[viii] http://meillionydd.bangor.ac.uk/documents/Booklet.pdf
[ix] http://finds.org.uk/
[x] e.g. http://www.dolldivine.com/
[xi] A discussion of citizen science/crowd-sourcing is outside the scope of this paper, but will be addressed in future writing about this project, if needed.
[xii] http://heritagetogether.org